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ABSTRACT

This publication is one of three books containing energy-related student activities at various grade levels. This particular book is concerned with energy technology. The activities correspond to a number of behavioral objectives and are further grouped according to suitability for pupils in grades 7-9. Interdisciplinary in approach, the activities are taken from the disciplines of science, art, social studies, mathematics, music, language arts, English, and manual arts. The book contains some charts and illustrations, as well as a listing of supplementary references. (MA)

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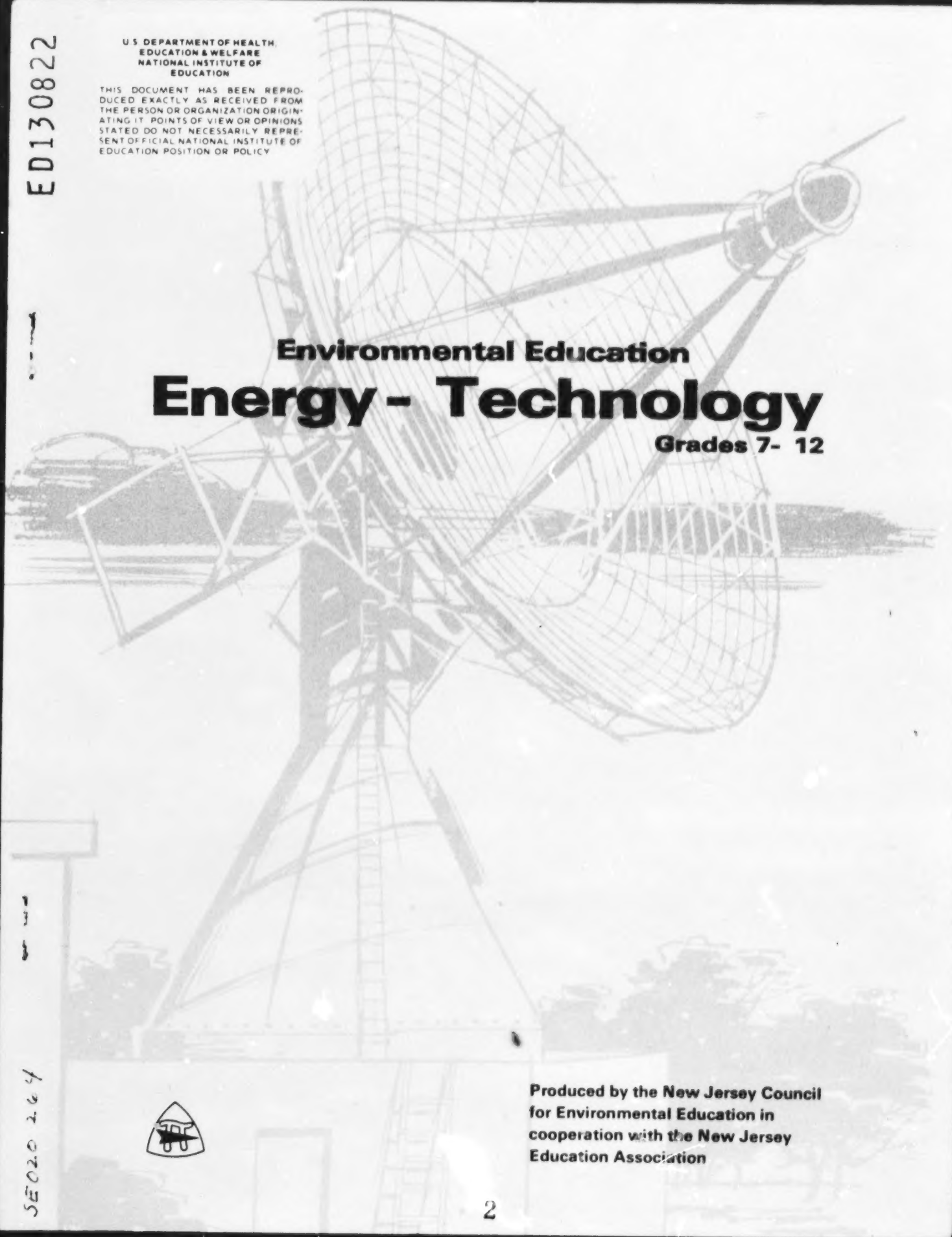

Environmental Education

Energy - Technology

Grades 7- 12

SE020 464

Produced by the New Jersey Council for Environmental Education in cooperation with the New Jersey Education Association

ENVIRONMENTAL EDUCATION

ENERGY - TECHNOLOGY

Grades 7 - 12

THE NEW JERSEY STATE COUNCIL FOR ENVIRONMENTAL EDUCATION
at Montclair State College
Upper Montclair, New Jersey
07043

Dr. Edward J. Ambry, Director

In Cooperation With

THE NEW JERSEY EDUCATION ASSOCIATION

Pursuant to

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ENERGY - TECHNOLOGY

INTRODUCTION

The activities in this book have been selected from a Computer Based Resource Unit entitled, "Energy - Technology". It is one of thirteen units in the "Environment and the Quality of Life" series produced by the New Jersey State Council for Environmental Education, a federally funded project under Title III, Sec. 306 Elementary and Secondary Education Act, directed by Dr. Edward J. Ambry at Montclair State College, Upper Montclair, New Jersey.

Dr. Richard Lowell, formerly Curriculum Specialist on the Council staff, coordinated the production of "Energy - Technology" under the direction of Edna Doll, Assistant Director in Charge of Curriculum.

All the activities are related to learner objectives and are grouped for pupils at various grade levels. Not all objectives have activities for all grade levels. Teachers may adapt, adopt, correlate, separate or use these activities in a variety of ways which they determine will meet the needs of their students. Activities may be used with large groups, small groups or for individual instruction.

Also available at this time are two similar books containing student activities, entitled, "Energy - Society" (grades 4-12) and "Energy - Transportation" (grades K-12). For information, write to the New Jersey State Council for Environmental Education, Montclair State College, Upper Montclair, New Jersey 07043.

Teachers desiring more complete information on these subjects may request Computer Based Resource Units. CBRU's include activities, content items which serve as background information for teachers and/or students, measuring devices, and lists of books, pamphlets, articles and multimedia materials, all related to specific learner objectives. CBRU's are available to all New Jersey teachers through the combined efforts of the New Jersey State Council for Environmental Education and the State Department of Education. Refer to the CBRU Resource Manual located in each school and fill out the required CBRU Request Form.

Thirteen Environmental Education CBRU's have been developed by the Council with the aid of consultants and specialists in Environmental Education, and Curriculum Development Teams, composed of teachers from all grade levels, teaching in urban, suburban, and rural districts, representing all sections of New Jersey. It is the desire of the curriculum developers that these units provide for exciting and relevant learning experiences for students. They embody educational materials which allow teachers a wide selection of alternatives for classroom use and for individualized approaches to the needs of pupils in elementary and secondary instructional programs.

ACKNOWLEDGEMENTS

We wish to thank members of the Council who aided in the production of this book: Marie Gostin, Arthur Thornton and Lorraine Wirths.

Art work by Deborah Healy, free-lance artist.

ENERGY - TECHNOLOGY

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OBJECTIVE: To discuss the role of fossil fuels in the production of energy.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:

1. Interview your gas station manager. Questions you might want to ask are - Where does his fuel supply come from? How often are the deliveries? Are they adequate? Has he noticed any trends in terms of numbers of customers? Types of fuel requested, etc. What problems is his business facing? What is his future outlook? (If possible, tape the interview and share it with the class.)

SUBJECT: Science, Language Arts

ACTIVITY:

1. Organize a presentation showing how fossil fuels are formed and how these fuels are utilized in the United States. You might share your presentation with a younger class.

2. Correctly identify the three most important fossil fuels. Write a short paragraph on each telling where they are obtained, how they were formed, means of transporting, and use.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Art

ACTIVITY:

1. Each student will choose the sign presently used by any well-known oil company gas station and redesign it, making it more eloquent of what is being sold. If desired, each student could also redesign, using the same motif, other things used in the trade (i. e. map covers, car bags, credit cards, pump heads, etc.). When finished, mount all mock-ups on display board. As an alternative, use the sign or trademark of a local power utility.

SUBJECT: Science, Social Studies, Music, Art, Mathematics

ACTIVITY:

1. Prepare a presentation showing the sources of energy used for heating buildings from 1850 to the year 2000. The presentation may be in the form of a graph, song, pictorial representation, or a three dimensional display or as a pantomime dramatization. Has the use of fossil fuels increased or decreased?

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. Of the four grades of coal (anthracite, bituminous, subbituminous, and lignite), it has been stated that anthracite is the most valuable form. Using a geology or earth science textbook, make a list of the properties of these types of coal including such features as heat of combustion, sulphur content, ash content, moisture, availability, etc. From this list determine which is the most valuable form - which is the second most valuable form. How does sulphur or ash content influence the uses to which coal can be put? What steps must be taken if we are going to use all of the coal available and yet preserve our environment.

SUBJECT: Science, Social Studies

ACTIVITY:

1. Recent discoveries of oil, shale and coal have been found in regions currently not in the transportation net of our energy flow. On a map of the United States identify the areas of the country where oil shale deposits and coal fields have recently been discovered. In view of the transportation costs, will the price of these new sources of energy increase or decrease? What alternatives might be possible to decrease cost. (An interesting article on this subject is "Economic Geography of Energy" in the September 1971 'Scientific American'. Included is a chart which shows the flow of natural gas and crude oil in the United States.)

SUBJECT: Science, English, Social Studies

ACTIVITY:

1. Research and describe five products made from fossil fuels, such as coal and oil, and indicate how they are used. Then, identify or create a substitute for each, and design an advertising campaign for one of the substitutions. Considerations to keep in mind are the types of appeals most likely to sell the product - comparative cost, ease of use, amount of pollution produced in manufacturing and/or in use, product appeal, etc. The campaign design should include thumbnail sketch and an explanation of how your product is now better. If desired, the students can follow this exercise with a role play of the part of ad men presenting their campaign to the rest of the class.

OBJECTIVE: To analyze the process of solid and liquid fuel gasification.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science, Language Arts

ACTIVITY:
1. Write a paper on the topic, "Natural Gas is a Versatile Fuel". The paper need not be long, but should be accurate and well written.

SUBJECT: Science, Art

ACTIVITY:
1. Draw a map of the world and locate areas rich in natural gas. Is the gas found in areas where it can be used? If not, how is it transported?

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:
1. Write to Public Service Electric and Gas Co. Find out about their synthetic natural gas process What does the term mean? How is synthetic natural gas produced? How is it stored? What are the environmental hazards? Since gas is sometimes in short supply in some areas of the country, why isn't more made?

SUBJECT: Science, Art, Manual Arts

ACTIVITY:
1. Using notes or other reference material, construct a simple diagram or model showing the major components of a gas turbine electrical generator. All parts must be correctly named. Include a brief paragraph correctly explaining the diagram.

SUBJECT: Science

ACTIVITY:
1. Plan a lesson for a fourth grade class describing the basic process of liquid and solid fuel gasification. Go over the lesson with your teacher. After you have perfected it, actually teach the lesson to a fourth grade.

SUBJECT: Science, Language Arts

ACTIVITY:
1. Write a review of an article you have read on solid and liquid fuel gasification.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. Individual or group research -
   Find out what gasification of fossil fuels is. Report on one method as it is being developed in the U. S. today. Some questions to be considered are - what problems are associated with the plant? What are the advantages? Where would the Bi-Gas process be used? Can the gas be transported to manufacture energy at other sites? If so, how? What do you think the future for this method is in the U. S.? What are the effects on the environment? (Resource - the October 6, 1971 issue of 'Science,' "Gasification - A Rediscovered Source of Clean Fuel" for information on two of these processes.)

2. Individual or group research -
   It is estimated that known U. S. natural gas reserves will last only 10 more years. One way to increase our supply is to manufacture gas (methane) from other fossil fuels. Research a U. S. method used in foreign countries and in this country (e.g., naptha gasification in Japan, England and West Germany). Include the chemical equation, a description of the process, by-products, use of by-products in other processes, incentives - if any - for developing these processes, and the future for this process.

3. If you have a knowledge of chemistry, make a study of the various reactions used in the processes of manufacturing SNG (synthetic natural gas). Which reactions are exothermic? Which are endothermic? Is the energy available in the SNG more than the energy input? Why has coal gas been a non-efficient source of energy until recently? What problems of a chemical engineering nature have to be solved for the gasification process to become commercially feasible? (See the October 6, 1971 issue of 'Science,' "Gasification - A Rediscovered Source of Clean Fuel" for information on this topic.)

SUBJECT: Science, Social Studies, Manual Arts

ACTIVITY:

1. Create models of how gas is produced from two fossil fuels. Show all levels of production and effects on the environment at each level. Identify where these fuels can be located and the available amounts. Also, identify research or existing processes to make this fuel more economical and less detrimental to the environment. What incentives, if any, are there to make this method more usable?

OBJECTIVE: To investigate power gas and combined cycles as a source of clean power from fossil fuels.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:

1. List the environmental problems most commonly associated with current electrical generating facilities. Show how each of these environmental problems would be affected for better or worse if a combined cycle power gas generating facility were used.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. Why does the combined cycle generator give a better efficiency than conventional generators? Part of the answer is to be found in the first law of thermodynamics. In a brief form, the law says that the efficiency of an engine, E, equals heat absorbed minus the heat released, divided by the thermal energy put into the system, multiplied by 100 percent:

$$E = \frac{Q(Hot) - Q(Cold)}{\text{Energy Input}} \times 100 \text{ percent}$$

Or, $E = (1-Q(Cold)/Q(Hot) \times 100$ percent

Further information can be found in books under the heading Carnot Cycle or the laws of thermodynamics. Because the power gas has less energy to release than natural gas, does the increased efficiency of operation make up for the decreased amount of energy available? Explain to your class.

2. Research the method of producing electricity which makes use of the combined cycle generator system, called "Oilplex". Create a diagram that explains the various stages in the production of electricity by this system and where the greater efficiency is achieved. Explain to your classmates the advantages and disadvantages of this system and its commercial uses. (The October 1972 issue of 'Scientific American', "Clean Power from Dirty Fuels" by Arthur Squires, includes information on this topic.)

3. Demonstrate a knowledge of the concept of combined cycle generators by describing verbally, in written form or via a diagram a combined cycle generating system involving a minimum of two cycles.

OBJECTIVE: To determine the increases in efficiency which could be derived from applying coal to the production of magneto-hydrodynamic power.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:

1. Create a diagram of the MHD power cycle and identify the elements of the cycle. Explain to your classmates why the MHD cycle is more efficient than the fossil fuel cycle for producing electrical energy, why a seed must be added to the burning gases, why preheated air is injected into the combustor, and why the MHD cycle is better in terms of pollution than the fossil fuel cycle. (See 'Problems of Our Physical Environment' by Joseph Priest, Addison-Wesley Publishing Company, 1973, for information on the MHD cycle.)

2. How is electricity generated in a MHD generator? Get several long pieces of wire, a magnet, and a galvanometer or microameter. Attach both ends of the wire to meter. Place the wire near the magnet. With both the wire and the magnet stationary, does any current flow in the circuit? Now, move the wire near one end of the magnet. Is there any current flowing in the circuit now? Try various wires to see which of the wires is the best. Make some loops in the wire. Pass the wire near one of the ends of the magnet. Is there more current now than before? Experimentally determine the configuration that gives the maximum amount of current flow. What are the factors that determine the amount of current flow in the circuit? How do the pieces of equipment in the experiment compare to the parts of a MHD generator?

SUBJECT: Science, Mathematics

ACTIVITY:

1. It is well known that the United States imports oil from the Middle East. Where does the United States get its coal? What regions in the world have the largest known coal reserves? If the United States uses MHD generators to produce 45 percent of its electrical production by the year 1990, how long will United States known coal reserves last? Present your research with a series of charts and maps.

SUBJECT: Science, English, Art, Social Studies

ACTIVITY:

1. Assuming the magnetohydrodynamic electrical generators were commercially available and widely in use by the year 1985, resulting in a shift away from oil, what would happen to large oil companies? How would this effect the United State's trade balances? You may have a choice in the way you present your findings - a written or oral report or the development of a pictorial review.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:
1. List some advantages to be derived from burning coal in a M.H.D. generator for electrical power production as opposed to burning coal for electrical power production in a conventional generator.

SUBJECT: Science, Language Arts

ACTIVITY:
1. Obtain additional information on M.H.D. electrical generation by compiling a list of at least five articles, reports, or summaries from a variety of sources on the subject of M.H.D. power generation. Briefly summarize at least one of the articles.

SUBJECT: Science, English

ACTIVITY:
1. Magnetohydrodynamic converters have been viewed as valuable and promising electrical generating alternatives, based on the fact that they contain no moving parts and therefore eliminate one step in an energy conversion process. Read carefully an article on this subject such as Claude M. Summer's article entitled "The Conversion of Energy", published in 'Scientific American' (Volume 224, No. 3, September 1971). In light of what you learn about the conversion of energy, evaluate these claims for the potential of magnetohydrodynamic converters. Report your findings to your class.

SUBJECT: Science, Language Arts, Art

ACTIVITY:
1. Display a knowledge of the basic operating principles of a M.H.D. generator by outlining verbally, in writing, or by diagram the essential components of a M.H.D. generator from the fuel input to the electrical output.

OBJECTIVE: To explain the general principles of power production in a fission nuclear reactor.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science, English, Social Studies, Art

ACTIVITY:
1. Arrange a visit to a nuclear power plant in your state (e.g., Oyster Creek, N. J. or Indian Point, N. Y.). Prepare questions ahead of time to ask employees of the plant. Write a newspaper report of your trip and illustrate, if possible, with photographs and diagrams. Keep in the classroom for reference, or share with another class.

SUBJECT: Science, Manual Arts, Art

ACTIVITY:
1. Make a model of a nuclear energy plant. Explain to a younger class how it works and the effects on the environment.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:
1. Identify two heavy metals which can be used as fuels in fission reactors. Why are they usable over other minerals? Where are they obtained?

SUBJECT: Science, Language Arts

ACTIVITY:
1. Discriminate between nuclear fission and nuclear fusion by writing a clearly stated paragraph outlining the elements of these two processes.
2. Explain to a younger class how a nuclear reactor works. Go over your explanation with your teacher before presenting it. Make your talk as graphic as possible.

SUBJECT: Science, Social Studies, Language Arts

ACTIVITY:
1. Write a biographical sketch on one of the pioneers of nuclear research (Einstein, Fermi, etc.).

SUBJECT: Science, Art, Manual Arts

ACTIVITY:
1. Draw a diagram of a water-cooled nuclear fission reactor including at least four major components. Instead of a diagram, you might want to make a model.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. The particles that are released during the fission of U235 have a combined energy of 200 MEV. The particles that are produced share the energy. Assume that one neutron carries 1 MEV of energy. If that neutron is to collide with another U235 nucleus to cause another fission, it must lose some of its energy. The probability that a U235 nucleus will capture a neutron and undergo fission is 100 times greater at a neutron energy of 10 EV. than at 1 MEV. To slow the neutron down, a moderator is used. If water is used, the neutron loses 8/9 of its energy if it collides with a heavy hydrogen (duterium) nucleus. How many collisions must it undergo to have an energy of 10 EV.? The neutron loses only 2/13 of its energy if graphite is used as the moderator. How many collisions does the neutron have to undergo to get to 10 EV. if graphite is used as the moderator?

2. Construct a list of major components of a nuclear fission reactor. To the right of each component, briefly describe its function. To the right of its function, briefly describe the type of hazard which would occur if this component failed.

3. Demonstrate an understanding of the difference between the process of fission and the process of fusion by listing some problems associated with fission reactors which would not be associated with fusion reactors.

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:

1. Research the problem of thermal pollution to the water cooling system of a nuclear fission reactor. Report your findings to the class.

SUBJECT: Science, English

ACTIVITY:

1. One of the most interesting aspects of fast breeder reactors is their ability to produce more fuel than they consume. This ability to almost defy the laws of logic is a very interesting process. Prepare a report on the mechanism by which fast breeder reactors produce more fuel than they consume. (You might wish to use as a reference the article, "Fast Breeder Reactors" by Seaborg and Bloom in 'Scientific American', Volume 223, November 5, 1970.)

OBJECTIVE: To identify some of the pro's and con's of nuclear power.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Social Studies

ACTIVITY:

1. The United States Federal Government seems to have committed itself and the nation to power production through the use of nuclear reactors and nuclear fast breeder reactors. Write to the Government Printing Office, Washington, D. C. and obtain copies of official government publications on nuclear and fast breeder reactor programs. Read these documents carefully and decide whether or not they present an objective view of the positive and negative aspects of nuclear power. Report to the class.

SUBJECT: Science, Social Studies, English

ACTIVITY:

1. Power companies have been placing numerous full page advertisements in local and national newspapers advocating the construction of nuclear generating facilities. By carefully reviewing local and national newspapers, find a number of examples of these advertisements. What companies are publishing them? Why are these companies advocating nuclear power? Are they presenting an unbiased view? As a class project, construct a comparable advertisement which outlines all of the reasons why nuclear power generators would not be attractive in your local area. Perhaps a newspaper will publish all or part of your ad as a public service, or perhaps you can obtain financial backing from some group to purchase advertising space to publish your views.

2. Recently, critics of nuclear generating plants have pointed out that the quality of construction in these plants has been very poor. Using an index to a resource such as the New York Times, research articles on this topic and prepare a report on the implications for the class.

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:

1. Write a magazine article on the pro's and con's of nuclear power. Include diagrams and pictures. You may want to share your article with your classmates in mimeograph form. If, in the estimation of your teacher, the article is really worthy, you might try to get it published.

2. Collect, over a period of time, some articles from newspapers and magazines on the pro's and con's of nuclear power. Summarize the articles.

3. Write a report on the biological effects of radiation. Identify at least two major results of radiation damage in living organisms.

4. Report to your classmates some of the advantages and some disadvantages of nuclear power generators over conventional fossil fuel power generators.

GRADE LEVEL: 10-12

SUBJECT: Science, Social Studies

ACTIVITY:

1. The history of nuclear energy and the nuclear industry in America has been completely and intimately associated with the government agency known as the Atomic Energy Commission. This relationship and the association has frequently been criticized by persons who claim that the dual role of the Atomic Energy Commission - namely, to promote nuclear energy and to set the standards of safety for nuclear energy, produce an inherent, inescapable conflict of interest. Investigate the history of the development and operation of the Atomic Energy Commission. Find evidence which either supports or refutes the conflict of interest. Discuss and/or speculate about what direction the nuclear industry would have taken if the Atomic Energy Commission had never been created. If evidence can be found to support the contention that conflict of interest within the Atomic Energy Commission exists, draft proposals for improving the situation.

SUBJECT: Science

ACTIVITY:

1. With diagrams and a written explanation, compare the nuclear reactor with the steam generating system for producing electrical energy. What differences exist between the two systems? What are the similarities between the two systems? What are some of the safeguards taken to reduce the risk of nuclear pollution? (A good reference for this information is 'Scientific American', September 1971, an article entitled, "The Conversion of Energy".)

2. Some of the common radioactive elements formed in nuclear reactors and their respective half-lives are given below.

A.	Tritium	12.26 yrs.
B.	Strontium	28.8 yrs.
C.	Cesium	30.2 yrs.
D.	Iodine	8.02 yrs.
E.	Krypton	10.76 yrs.
F.	Xenon	5.27 days

Write a brief paragraph on each of the following points which you can share with a member of your family or a classmate - Why are some of these nuclides considered very dangerous? (Hint - a Tritium atom has the same chemical properties as a Hydrogen atom commonly found in water). Can atomic pollution really be stopped? Suggest some ways to protect against nuclear pollution. Identify other radioactive materials that are dangerous. What are the biological effects of radiation?

3. One of the terms frequently used when discussing radioactivity or nuclear reactions is half-life. What does the term mean? Make a graph of the following data. Plot the number of counts per second on the y-axis and the time on the x-axis.

Data for the Decay Rate of 137Ba

Time (Min.)	Counts per Second
0.0	4617
0.6	3963
1.2	3332
1.8	2904
2.4	2542
3.0	2114
3.6	1820
4.2	1541
4.8	1279
5.4	1151
6.0	960
6.6	789
7.2	728
7.8	603

What is the half-life of 137Ba? Use semi-log graph paper and plot the same data. The second graph is more useful or easier to use than the first. Why?

OBJECTIVE: To explain the general operating principles of nuclear breeder reactors.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. It has been stated about breeder reactors that you get more fuel out than you put in. From the viewpoint of conservation of mass and energy, how is this possible? To clarify this for yourself, think about the following. In an ordinary nuclear reactor using 235U (Uranium 235) for fuel, what is the minimum number of neutrons that can be released in a fission reaction to maintain a self-sustaining process? In breeder reactors, which use 239Pu (Plutonium 239) for fuel and 238U (Uranium 238) for fertile nuclei, what is the minimum number of neutrons released in a fission to maintain a self-sustaining process as well as the replacement of the fuel? Write a report of your findings.

2. Demonstrate a knowledge of the difference between simple fission reactors and fast breeder fission reactors by listing a minimum of two ways in which they differ.

3. Given the statement, "Fast breeder reactors offer a greater promise as an alternative energy source than simple fission reactors", list a minimum of two reasons which accurately support this statement.

4. Demonstrate a knowledge of the operating components of a breeder reactor by drawing a simple diagram in which a minimum of five components of a nuclear breeder reactor are accurately identified and appear in accurate relationship to one another.

OBJECTIVE: To analyze the potential of geothermal energy as a major future energy source.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:

1. List some valid reasons supporting the statement, "The potential of geothermal energy as a widely used power source is limited." Explain your reasons.

2. Accurately locate on a map of the United States and/or on a map of the world, those areas which are currently considered promising locations for the development of geothermal energy facilities.

SUBJECT: Science, English

ACTIVITY:

1. Write a paper on geothermal power. You might want to include the answers to the following questions: What geological requirements are necessary for geothermal power to be available at the earth's surface? Locate areas in the United States which are currently using geothermal energy or plan to do so in the near future. What areas of the world are currently using geothermal power? What do all of these areas have in common in geothermal terms? What are some of the problems of using geothermal power? If you can, illustrate your paper with maps, charts or pictures.

SUBJECT: Science, Art

ACTIVITY:

1. In various parts of the world there are natural steam vents, such as geysers, which are powered by geothermal energy. The steam issuing from these vents could be harnessed to produce electricity. Consult geology textbooks or other resources to determine what conditions are necessary for a geyser to exist. Draw a cross-section of the earth showing a geyser. Diagram a power facility which could be built on top of a geyser to tap its steam power to generate electricity. Modify the original drawing to make the generator part of a combined cycle generator.

2. Draw a diagram showing how geothermal energy is used. Identify the various parts of the mechanical part of the operation. Explain the diagram to the class. As an extra bit of information, you might want to include a diagram of the geology of a geothermal area. (A good reference is in January 1972, 'Scientific American' in an article called "Geothermal Power".)

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:

1. Research how geothermal power is used in Greenland and/or other places in the world. Write a report of your findings. Include diagrams, graphs, etc.

GRADE LEVEL: 10-12

SUBJECT: Science, English

ACTIVITY:

1. In California, the Pacific Gas and Electric Company is currently exploiting or planning to exploit geothermal energy for the production of electricity. Write a letter to Pacific Gas and Electric requesting information on their exploitation of geothermal energy. Report the information to the class.

SUBJECT: Science, Art, Manual Arts

ACTIVITY:

1. The entire process of geothermal power production and the phenomenon of geothermal energy is dependent on the structure of the earth, and the differences in temperatures between various parts of the earth. After consulting geology texts or other sources such as encyclopedias to obtain information about the structure of the earth, draw a detailed diagram or construct a model showing the various regions of the earth from the core out to the crust. Indicate the relative range of temperatures found in each region and define the term "geothermal gradient". Could geothermal steam be used as part of a combined cycle generator?

SUBJECT: Science, Mathematics

ACTIVITY:

1. Make a report on the following aspects of geothermal energy. From mining operations, it is known that for every 1000 feet one digs deeper into the earth, the temperature will increase by approximately 10 degrees. What would be the temperature at the point where the crust of the earth meets the mantle - a depth of approximately 20 miles below the surface? Is this temperature hot enough to melt rocks? Could you do this anywhere, or would some places be better than others? (Consider the thickness of the earth's crust at various places on the earth.) How could this heat be used?

OBJECTIVE: To analyze the potential of solar energy as a major future energy source.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:

1. Solar energy falls on all parts of the earth continuously during the daylight hours. It is free and anyone with an inclination and knowledge can tap it and utilize as much of it as they want without cost. In light of the fact that our country and the world is currently experiencing a severe energy shortage, attempt to answer the question - "Why do we not utilize solar energy to a greater degree?" Perhaps a representative of your local power utility would comment on this question. Find information in newspapers and magazines.

SUBJECT: Science, Language Arts

ACTIVITY:

1. Demonstrate an understanding of the relationship between solar energy and fossil fuel energy by writing an essay on "All Fuels Are Solar Energy."

SUBJECT: Science, English

ACTIVITY:

1. You are a newspaper reporter assigned to science news. Write an article or a series of articles on solar energy. Remember you are writing for the general public so your work will have to be accurate and easily understood. Think of attention getting headlines. You might want to cover some of the following points - How do the amounts of available energy compare (solar, fossil fuels, geothermal, tidal, etc.)? How is solar energy used? How could it be converted to electrical energy? One way of storing solar energy is through the process of photosynthesis. Where is the energy stored in this process? How could the stored energy be used? (Another energy form might be substituted.)

SUBJECT: Science, Art, Manual Arts

ACTIVITY:

1. Design a home in which you would enjoy living that does not make use of standard forms of power, but which relies on solar energy.

2. Design and build a scale model of a building which would be heated by the sun. Explain how it would work.

SUBJECT: Science, Manual Arts

ACTIVITY:

1. Design a toy or game that has the theme of solar energy. Include clear instructions, and an interesting point to the game. The product should be environmentally sound.

2. Plan a greenhouse. What materials do you need? What environment must you create? What use do you make of the sun? Research the term "greenhouse effect" and explore how the greenhouse you have constructed is related to the "greenhouse effect" of the total earth.

3. Following individual research into simpler methods of implementing solar energy to heat homes, construct a simple model of this method of energy usage.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. The relative costs of energy for various energy sources are listed below:

Energy System	Cost (Dollars/KWH)
Central Power Plant	0.02
Magnetohydrodynamics Generator	0.02
Iron-Nickel Alkaline Storage Battery	0.10
Gasoline Engine	0.20
Fuel Cells	4.00
Silicon Solar Cell	6.00
Mercury Batteries	500.00
Electric Watch Battery	70,000.00

Discuss - With respect to other energy sources, the solar cells are very expensive. What are some of the advantages that make them an attractive energy source for the future? Besides solar cells, in what other ways can the energy from the sun be used? (If you are interested in pursuing this area further, you may wish to look into homes both in the United States and Israel that use solar power.)

2. Obtain a number of solar cells from sources such as the Edmund Scientific Company, 300 Edscarp Building, Barrington, N. J. 08007 (Phone 609-547-3988). Using the cells to simulate local electrical generating facilities, build a model community arranging the solar cells in a manner which efficiently provides power to the community with a minimum of transmission lines. Compare this to a similar model using a central power generator (conventional steam turbine) and conventional transmission lines.

3. Photovoltaic cells are commercially available for the hobbyist and experimenter at a cost as low as $.50 each. Obtain a solar cell and demonstrate the general principle of photovoltaic conversion to electricity. (Solar cells can be obtained from Edmund Scientific Company, 300 Edscarp Building, Barrington, N. J. 08007 - Phone: 609-547-3488).

4. Plan some ways in which solar heat or energy could be used in your school building. As a reference, you might want to use a book called Research, Design Construction and Evaluation of a Low Energy Utilization School. Sponsored by the National Science Foundation. $3.50. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, Stock No. 3800-00194. You might also glean some ideas from a free kit from your local Bell Telephone Co., called The Bell System Experiment, No. 2 Kit.

5. Solar energy offers the potential for decentralized power production. Current power utilities have a great interest at stake in controlling central power production. Write a speculative scenario depicting how electrical utilities might block the broad development of local solar facilities.

SUBJECT: Science, English

ACTIVITY:

1. It is often said that fossil fuel power, wind power, water power in the form of hydroelectric and tide power, and power obtained from burning any organic fuel all represent a form of solar energy. In a well written, carefully researched essay, explain the previous statement. Are there any exceptions to the statement? In other words, are there any forms of energy which are not ultimately derived from the solar energy?

SUBJECT: Science, Mathematics

ACTIVITY:

1. Assuming that the solar radiation received outside the earth's atmosphere is $0.14/cm^2$, show that the energy in the form of light that is emitted by the sun is 4×10^{20} megawatts. The distance from the earth to the sun is 1.5×10^8 km. The radius of the earth is 6.3×10^3 km. If the average amount of energy that falls on the earth's surface is 0.07 watts/cm^2, how efficient is the earth's atmosphere at transmitting solar energy? What happens to the energy that does not get to the earth's surface?

2. By the year 2000, the United States will consume $10{,}000 \times 10^9$ kilowatt/hr. of electrical energy. Assuming that the United States is 3000 miles by 1000

miles, what is the surface area of the United States in square miles? There are 2.59×10^9 cm^2 $mile^2$. What is the surface area of the United States in square centimeters? If one percent of the surface of the United States were used to convert solar energy to electrical energy, how much energy would be available? (The solar energy at the earth's surface is 0.07 watts/cm^2.) If the efficiency of conversion is 1 percent, could the energy needs of the United States be satisfied in the year 2000 by solar energy?

SUBJECT: Science, Art, Industrial Arts

ACTIVITY: 1. Numerous proposals have been advanced for utilizing solar energy to generate electricity. While many of these proposals appear to be reasonable and feasible, they would not be applicable to mobile energy needs such as automobiles, trains and aircraft. Design and diagram a system which in some way could utilize solar energy for powering transportation devices.

OBJECTIVE: To describe the potential utility of several kinds of photovoltaic cells for the conversion of solar energy.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:
1. Research the potential for power from the sun through solar cells. Your report should include whether or not you think solar cells would be more applicable to local and home use than current methods of electrical generation and why or why not, and what type of impact the local use of solar cells would have on energy transmission problems. (See 'Science', Vol. 162, No. 857, 1968, "Power from the Sun, Its Future" for information on this topic.)

SUBJECT: Science, Art

ACTIVITY:
1. Display an understanding of the requirements necessary for the effective operation of photovoltaic cells by identifying on a map of the United States those areas which receive the greatest amount of annual sunshine, and therefore provide the best environment in which photovoltaic cells can operate.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:
1. Identify two or more types of photovoltaic cells by naming the materials of which they are constructed.

SUBJECT: Science, Language Arts

ACTIVITY.
1. Correctly define a "photovoltaic cell" in a well written paragraph.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:
1. Information on utilization and conversion of solar energy in a variety of areas is available from the Edmund Scientific Company (300 Edscarp Building, Barrington, N. J., 08007, Phone 609-547-3488). Obtain the Edmund Catalog and review the section on solar energy for project ideas. Select a project that you can present to your class that explains a method of solar energy conversion. Be informed so that you can answer your classmates' questions regarding the use of solar energy.

2. One proposed method of obtaining electrical energy from the sun is to place a satellite in synchronous orbit above the earth. Research this method of energy production and find out about the pro's and con's of its use. Present with visual aids to your classmates.

3. Of all the semiconductor devices to be developed, photovoltaic cells were among the first to be used. In a book on electronics or semi-conductors, examine the fundamental principles of semi-conductor devices in general and photovoltaic cells, in particular. Currently, solar cells have an efficiency of 13 percent. In the future, the efficiency may be raised to 20 percent. If there are no moving parts or losses of heat in the cells, why is the efficiency so low? (Remember, the efficiency of fossil fuel plants is in the neighborhood of 40 percent). Existing silicon cells develop about 0.5V. What does this imply about the numbers needed to power a house? Solar cells produce direct current. Most appliances in your house use alternating current - how can direct current be changed to alternating current?

SUBJECT: Science, Art, Manual Arts

ACTIVITY:

1. Display an understanding and appreciation of the potential of photovoltaic cells by designing a home in which photovoltaic cells supply at least part of the total energy requirements. Your design should show a minimum of photovoltaic cells arranged so as to catch sunlight and a storage system for the electrical energy produced, or some means of directly utilizing the electrical energy.

OBJECTIVE: To relate the problem of solid waste disposal to the potential of solid waste as an energy fuel source.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:

1. List some items in domestic garbage which would yield heat energy if burned. Explain how the process would work.

SUBJECT: Science, Social Studies

ACTIVITY:

1. Find out what is being done in your community with its organic garbage and what environmental problems result. Also, research alternative proposals for disposing of these wastes and the effects of the alternatives on the environment. Discuss with your classmates the economic, political and social reasons why the alternative solution might or might not be feasible.

2. Garbage, by definition, is something which has so little value that we throw it away. What happens to the refuse after it is put in a garbage can outside the house? Who picks it up? Is it a municipal refuse collector, or a private contractor? Does the family pay for this service directly, or is it part of the municipal tax bill? How much does it cost? What does it cost for the entire community? Where is the garbage ultimately disposed of, and in what way is it disposed of? Is it burned, or is it deposited in a landfill operation? What does the term "sanitary landfill" mean? Is there any best way for disposal of domestic refuse? Will the method of garbage disposal being used by your community be applicable on a long-term basis? Does it produce any form of pollution, either air pollution, water pollution or visual pollution? Does it pose any form of health hazard? Are there more attractive alternative forms of disposal, and if so, why are they not currently being used? Discuss these aspects of the subject.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. Identify some processes by which organic waste can be converted to synthetic fuels.

SUBJECT: Science, Art, Manual Arts

ACTIVITY:

1. Design a plant which would utilize heat from burning garbage in an incinerator to provide the energy to drive some productive process.

SUBJECT: Science, Social Studies

ACTIVITY:

1. Statistics indicate that the amount of solid garbage produced on a per capita basis by Americans has been growing steadily for some time. Conduct an analysis of the garbage which an average family produces and discards. What is it composed of? What components of our modern garbage can probably account for the major increase in the per capita volume? How does the garbage of a modern American household differ from that produced by the average American family 150 years ago? How did people 150 years ago dispose of their garbage? Did they have a disposal problem of any kind? Speculate on whether or not, and to what extent they might have practiced recycling of refuse. Roughly calculate the percentage of municipal waste produced in the town which is dry, organic material capable of being burned. Devise a plan by which your municipality could supply the town's total electrical needs by burning garbage and using the resulting energy to generate electricity. Does the municipality produce enough garbage to fill this need? If not, what are the possibilities for getting garbage from surrounding towns? Would the municipality have to buy it, or would other towns give it away, perhaps deliver it to some central location free of charge? Could such an operation be made profitable? Would it solve any problems besides waste disposal? Would it perhaps create problems that do not currently exist? If sufficient data is gathered on this project, perhaps the class or class representatives could arrange a presentation of the plan for some local governing body or municipality, or some central agency representing a group of individual municipalities.

2. Design an energy conversion system for your town which makes use of garbage. Include a "conversion station," recycling facilities, a method of transporting the garbage and a process by which the energy would be made available. Make your system as economically and environmentally sound as you can.

SUBJECT: Science, Social Studies, English

ACTIVITY:

1. The general subject of solid waste garbage as a resource has been discussed in an excellent article by C. B. Kenahan, entitled "Solid Waste - Resources Out of Place". Obtain a copy of this article, if available, and read it. Prepare a brief report on the conclusions of the article, paying particular attention to the potential for solid waste as an energy source. Report this to the class. Send copies to municipal officials and ask for their reactions to proposals for utilizing solid wastes as a resource rather than as a liability. (If the above resource is not available use the reader's guide in your library to find a similar article.)

OBJECTIVE: To identify the general principles of the nuclear fusion reactor.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:

1. Research the topic of fusion power and develop a presentation for your class. Some questions you may wish to consider are: Why is a magnetic field used to contain the plasma in a fusion reaction? What initial conditions must exist in the plasma before the fusion reaction becomes self-sustaining? What is the Lawson criterion for a self-sustaining reaction? Why did the Russian and American scientists change from the stellerator to the tokamak? What are the differences between the two? After your presentation, discuss with your classmates the future for this form of energy production. (February 1971 issue of 'Scientific American', "The Prospects of Fusion Power" includes information on this topic.)

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:

1. Explain one or more technical problems which remain to be solved before the process of nuclear fission can be commercially applied to the production of electrical energy.

2. Research the following items: Identify the two primary fuels used in the process of nuclear fusion. How are they obtained and how do they function?

GRADE LEVEL: 10-12

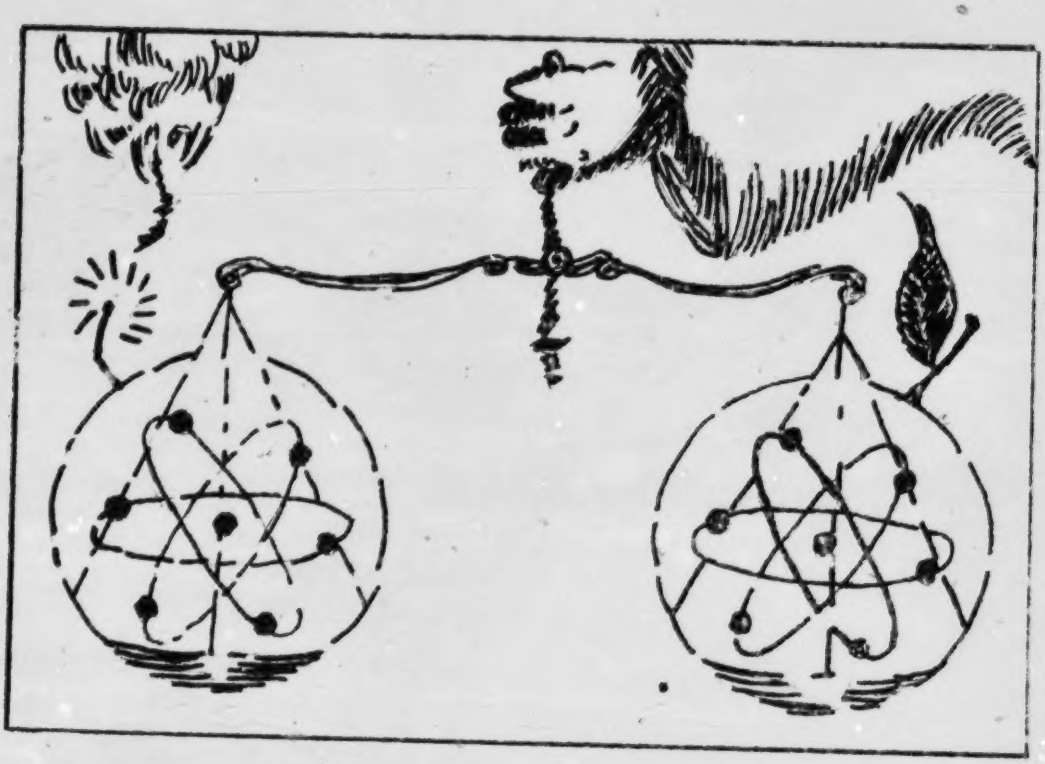
SUBJECT: Science, Mathematics

ACTIVITY:

1. Some students may question the availability of nuclear fusion fuels such as deuterium. Deuterium is one of the three known kinds of hydrogen atoms. The most available source of hydrogen is water. If the radius of the earth is 6500 km. and 2/3 of the earth's surface is covered with water, calculate the surface area of water on the earth. If the average depth of water at the earth's surface is 1 km., calculate the volume of water on the earth's surface. 1 $cm.^3$ of water weighs 1 gram. What is the mass of the water on the earth's surface? 6×10^{23} molecules of water weigh 18 grams. How many molecules of water are there on the earth's surface? Each water molecule

has two hydrogen atoms in it. How many hydrogen atoms are there on the earth's surface? One out of every 7000 hydrogen atoms is a deuterium atom. How many deuterium atoms are there on the earth? The deuterium and deteurium nuclear reaction yields 3.3 MEV. If each EV - 1.5×10^{-22} BTU's, how many BTU's are available by converting all the deuterium to another form of energy?

2. To understand the principle of a nuclear fusion reactor it is necessary to know how fusion is accomplished. For two protons to fuse together, they must come within about 10^{-12} cm. of each other. But, the two protons both have positive charges and thus repel one another. The energy associated with the repulsive force is energy (ergs) - E^2 (electrostatic units)/R (centimeters), where R is the separation of the two particles. The charge of a proton in electrostatic units is 4.8×10^{-10}. If the energy to bring them together is supplied by the temperature of the plasma, E = (3/2) KT, K = 1.38×10^{-16} ergs/^{o}Kelvin), show that the temperature T must be of the order of magnitude of millions of degrees Kelvin. Explain to your class.



OBJECTIVE: To evaluate the potential for fusion reactors using magnetic containment.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Language Arts

ACTIVITY:

1. Demonstrate an understanding of the concept of magnetic containment by writing a paragraph correctly answering the question, "Why is magnetic containment necessary for nuclear fusion reactors?"

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. In the magnetic containment type of fusion reactor, a magnetic field is used to contain the charged particles in the plasma. How does the magnetic field affect charged particles? Check your library or a science book to see how the magnetic field applies the force to the charged particles. How do the magnetic field and the charged particles have to be aligned to exert the maximum force - parallel to one another or at right angles? The magnetic force on charged particles is very small at large distances and is easily hidden by other forces. However, if your school has an oscilloscope, you have a source of charged particles that can be deflected by small magnetic fields. Set up the oscilloscope so that there is a straight line pattern on the screen. Bring a magnet near the screen. What do you observe? Bring the magnet near the side of the scope. What do you observe now? Be sure to use a relatively weak magnet so that you don't damage the scope. What do you think the effect of the magnetic field would be if the charged particles were protons instead of electrons? To check this out use the other end of the magnet. What are your observations now? How is the magnetic field produced in the magnetic containment devices used for fusion reactions. Explain to your class.

2. Research the topic of fusion power and find out about the devices developed to contain plasma. For the purpose of your report to the class, diagram several devices and show how the magnetic field is created in those devices. Draw a cross-sectional and plane view of the magnetic devices and show the magnetic field and the configuration of the plasma due to the field. Other questions with which your report should be concerned are - How is the plasma heated in these devices? Discuss with your classmates the future for magnetic containment fusion reactors. (Resource - February 1971 issue of 'Scientific American', "The Prospects of Fusion Power".)

OBJECTIVE: To evaluate the potential for thermonuclear power derived from laser fusion.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

1. Obtain from a source (such as the article "Fusion by Lasers" in the June 1971 issue of 'Scientific American') a diagram of a full scale laser fusion reactor plant. Identify the various parts of the plant. Find out how the energy is removed from the system. What similarities exist in this plant and fossil fuel plants? What are the differences? What is the efficiency of operation of the plant? If the efficiency is not very high, why is this type of plant proposed? Report your information to the class.

2. List at least two differences between devices utilizing the principle of laser fusion and devices utilizing the principle of magnetic containment fusion. Explain them to the class.

SUBJECT: Science, Art

ACTIVITY:

1. Construct a diagram showing in simple fashion how a laser fusion device might work. The diagram should show a device for multiple laser beams, and a mechanism for timing and dropping fuel pellets into the path of these multiple laser beams.

SUBJECT: Science, Art, Manual Arts

ACTIVITY:

1. Through the use of visual aids (i.e., diagrams, models or overlays) explain how a proposed laser fusion reactor works, how it differs from the more conventional magnetic containment type of fusion reactor starting with the laser beam itself and ending with the use of lithium to generate steam, identify the technological advancements that must be made for the laser fusion reactor to work, how this type of reaction differs from the more conventional type of fusion reaction, and how the energy is removed from the system. (See the June 1971 issue of 'Scientific American", "Fusion by Laser" for information on this topic.)

SUBJECT: Science, Language Arts

ACTIVITY:

1. Identify some technical problems remaining to be solved before laser fusion becomes a commercially viable reality by researching the topic and writing a paper about it.

OBJECTIVE: To discuss the limits of currently used methods of energy transmission.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:

1. One of the big factors in the cost and supply of energy is the transportation of it. Most people overlook this. Do some research on this topic. Consider the following points. Would it be better if the coal used to produce the power gas were shipped to another location, such as a centralized power station, or would it be better to produce the power gas at the mining site? If the power gas were produced at the mining site, would it be better to produce the electrical energy at the same site? In view of the fact that other services or products are also available from the production of the power gas, where do you feel the stations that produce the power and services from the power gas should be located? (If available, the September 1971 issue of 'Scientific American' includes a chart that shows transportation costs of various forms of energy in an article, "The Economic Geography of Energy" by Daniel Luten.)

2. List some alternatives to overhead transmission lines which are currently available or proposed for the transmission of electrical power.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:

1. You are a newspaper reporter caught in the blackout in New York City. Describe your experiences - what caused the blackout - and editorialize on how you think it could have been prevented.

SUBJECT: Science

ACTIVITY:

1. Identify some problems currently associated with underground power transmission and make a statement about their potential solution.

GRADE LEVEL: 10-12

SUBJECT: Science, Mathematics

ACTIVITY:

1. In the transmission of electrical energy, it has been stated that the higher the voltage, the lower the losses

of energy. Why should this be so? The power in an electrical circuit (power = the time rate at which energy is being created or lost) is defined as P = IV, where I = current in amperes, V = voltage in volts, and P = power in watts. This would appear to show that as voltage increases, so would the power. However, from another law of electricity (Ohm's Law) the voltage = current x resistance, V = IR. So P = IV can be written as $P = I^2R$. If the current is doubled and the resistance remains constant, what happens to the power losses when the current is tripled? The resistance of a wire, R, is proportional to the length of the wire and inversely proportional to the cross-sectional area of the wire. If you double the length of a wire and also double the diameter of the wire, how would this affect the resistance of the wire? If the current were constant, how would this affect the power losses? What would happen if you tripled all the dimensions of the wire. What are the practical limitations of transporting electrical energy by such devices as overhead transmission lines? Write a report covering these questions.

3. Research the topic of the cost of transporting energy. Chart your findings. If the energy source can be transported in more than one way (such as gas in a pipeline and in liquid form), show the cost of both ways. Also include, if possible, a time line that shows whether or not the costs are increasing or decreasing. Explain your findings to the class. Discuss with the class what the effects of newer energy sources (i.e., nuclear power, solar cells, fuel cells) might have on the costs of transportation. (The September 1971 issue of 'Scientific American', "The Economic Geography of Energy" is a source of information on this topic.)

SUBJECT: Science, English, Social Studies

ACTIVITY:

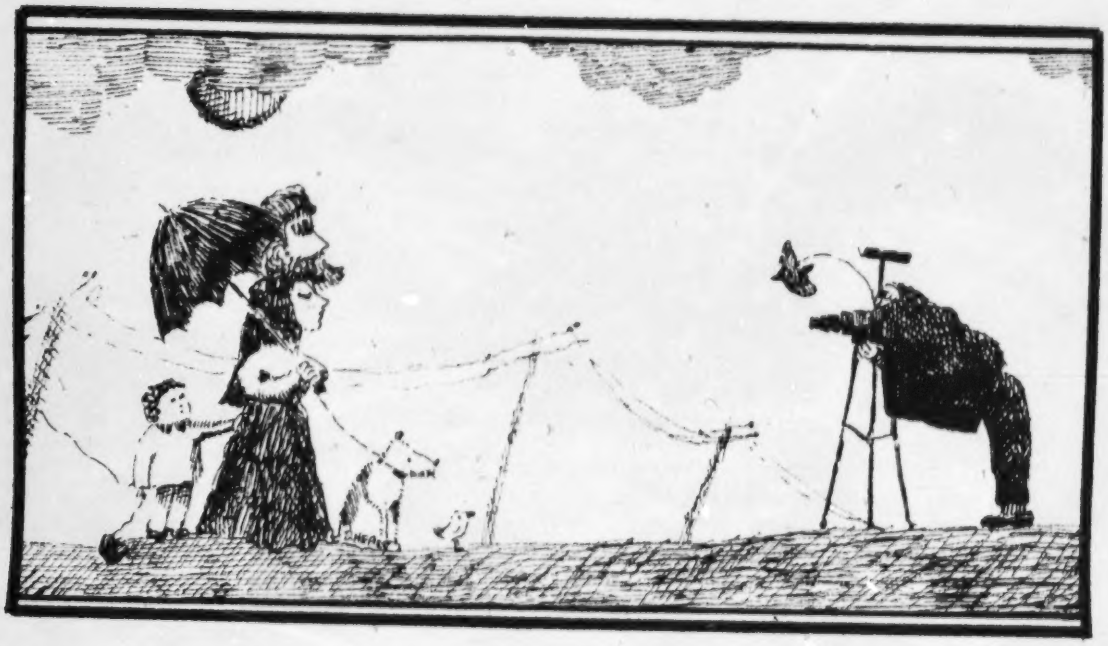
1. High voltage transmission lines and towers are a common sight in the American landscape. There are probably some in or very close to the town in which you live. Locate transmission power and lines near your home. Try to interview the people who live very close to these facilities and determine what their reaction to them is. In what unsuspected ways does living near transmission towers affect the quality of one's life?

SUBJECT: Science, Social Studies, Art, Language Arts

ACTIVITY:

1. Currently, the transmission of electrical energy in this country is carried out by overhead high voltage transmission lines. These can be observed criss-crossing residential and commercial neighborhoods in virtually any

part of the country. Obtain a series of photographs, either clipping them from magazines or by taking them yourself, of high voltage transmission lines which depict their aesthetic disadvantages. Attempt to select or take photographs which are as dramatic as possible. Assemble these photographs in a slide show with appropriate music and narration, or on a bulletin board or scrapbook of some type.



OBJECTIVE: To contrast selected proposals for new energy transmission methods with existing transmission technology.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:
1. Identify some problems associated with electrical transmission using current overhead high tension transmission lines. Report them to your class in some kind of pictorial representation.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:
1. In a paragraph or two describe a minimum of one advantage and one disadvantage of centralized power generation and dispersed power generation.

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:
1. Write a paragraph describing two examples of energy waste resulting from currently used energy transmission methods.
2. Identify a minimum of three methods of energy transmission. Explain advantages and disadvantages of each. This report could be done using diagrams or pictures.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:
1. Research the topic of superconducting materials in energy transmission. Questions to be considered: What are some of the materials which are superconductors? What is meant by superconduction? What materials lose their resistance to current flow at low temperatures? What is the range of temperatures involved with superconduction? How are these temperatures achieved? What are some of the problems of using liquid hydrogen and liquid helium? How do these problems effect the use of superconducting materials in energy transmission? What are some of the other uses of cryogenics? (See the March issue of 'Scientific American', "The Magnetic Structure of Superconductors" or 'Near Zero' by D. K. C. MacDonald in the 'Science Study Series', Anchor Books for information on this topic.)

SUBJECT: Science, Manual Arts, Art

ACTIVITY:
1. Construct a detailed diagram or three-dimensional model of a residential, industrial, commercial complex in which electrical transmission and distribution lines have been

laid out in an efficient manner. Points to consider are efficiency, aesthetics and convenience.

SUBJECT: Science, Social Studies, Language Arts

ACTIVITY:

1. Design an energy transmission system which could be applied in your community which would result in energy savings.

2. Write a report describing some of the problems involved in electrical transmission which need to be solved before alternatives to overhead transmission lines become a widespread commercial feasibility.

SUBJECT: Science, Mathematics

ACTIVITY:

1. One of the ways that the efficiency of the transmission of electrical energy can be increased is by using cryogenic or superconductors for power transmission. In this method of transmission of a material, usually an exotic compound of metals although some common metals can be used, is cooled to very low temperatures. The temperatures range from 4.2 to 20 degrees K. At these temperatures the wires carrying the electricity lose almost all resistance to current flow. Why should the resistance of a wire depend on the temperature of the wire? (A book on electricity should be able to supply the answer.) To show the effect of temperature on current carrying ability, make a graph of the following data for a niobium-tin cylinder.

Temperature (Degrees K)	Current (Amperes/Centimeter)
4	875
5	870
6	870
7	870
8	860
9	850
10	825
11	800
12	750
13	700
14	650
15	500
16	375
17	200
18	0

How can these low temperatures be achieved? What are some of the problems associated with the production of cryogenic temperatures?

OBJECTIVE: To evaluate the potential of fuel cells as a means of dispersed energy generation.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:
1. List some advantages to the electrical consumer which might be derived by switching from central power generation to electrical generation on a community or individual level by using fuel cells.

2. Demonstrate a basic understanding of the operation of a fuel cell by drawing a simple diagram identifying all of the major components of a hydrogen fuel cell.

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:
1. Write a brief description of the environmental impact of generating electricity from fuel cells. At least two environmental problems which would be improved by using fuel cells should be mentioned.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:
1. Prepare and present a chart that compares the efficiency of energy converters. In comparing the fuel cells to other devices in terms of efficiency, explain with the use of a diagram the operation of the fuel cell. What dangers and safety factors must be considered if fuel cells are to come into common use? (Resource - September 1971 issue of 'Scientific American', "Conversion of Energy".)

SUBJECT: Science, Language Arts

ACTIVITY:
1. One of the possible uses of the fuel cell is as the power source in an electric car. Explain how this works in a written report, or with diagrams.

OBJECTIVE: To evaluate the potential of liquid and gaseous hydrogen as an alternative to fossil fuels as a prime energy source.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:
1. Demonstrate a knowledge of how hydrogen might be applied as an energy source by listing some applications of hydrogen which could be used as a substitute fuel for gas, coal, or oil. Explain the process to your classmates.

SUBJECT: Science, English

ACTIVITY:
1. You are a trans-Atlantic passenger on the ill-fated dirigible Hindenberg. Describe your trip in a day-to-day diary. The day the Hindenberg exploded at Lakehurst, N. J., you were one of the few people saved. Explain what happened that terrible day. How did it affect the future of this mode of transportation?

SUBJECT: Science, Social Studies, Language Arts

ACTIVITY:
1. List and explain some of the advantages of using hydrogen as one of the fuels of the future, and explain the statement that hydrogen can be used in energy transmissions as an energy carrier. What are some of the advantages of the use of hydrogen? One of the disadvantages of the use of hydrogen is the so-called "Hindenberg Syndrome". In the 1930's hydrogen was used as the buoyant gas in blimps and dirigibles. The dirigible Hindenberg exploded and caught fire, killing a number of people when it was docked at the Lakehurst Naval Air Station in New Jersey. For safety reasons after the fire, hydrogen was no longer used in blimps and dirigibles. Many people still fear that the use of hydrogen as a fuel may lead to similar disasters. What can be done to allay this fear?
2. In a written composition explain how hydrogen might serve to improve or eliminate certain environmental problems. Compare the burning of gasoline or some other fossil fuel in air and burning hydrogen in air.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:
1. Consult an organic chemistry book to determine the approximate chemical composition of gasoline. With the aid of a chemistry book, chemist or chemistry teacher,

try to diagram the gaseous products that result from burning gasoline in air. Do the same for the reaction of gasoline burned in pure oxygen. Compare this to the gaseous products which would result from burning pure hydrogen in pure oxygen and pure hydrogen in air. Compare these four sets of reactions. Which produces the least gaseous pollutants which could be potential air pollutants? In what way can hydrogen be considered an energy carrier?

2. Using the chemical symbols for hydrogen and oxygen, write or diagram the chemical reaction which would occur when hydrogen is burned in pure oxygen.

SUBJECT: Science, Language Arts

ACTIVITY:

1. Given the statement, "Hydrogen fuel is not a primary energy source", describe in a well-written paragraph why the statement is correct.

SUBJECT: Science, Social Studies, Language Arts

ACTIVITY:

1. It has been suggested that using hydrogen in liquid form as an energy carrier would be one method of solving some of our energy problems. Consult a physics or chemistry textbook and determine the temperature of liquid hydrogen. (Hint - liquid hydrogen is very cold.) Energy applications were powered by liquid hydrogen. What are some of the hazards that would result from so much liquid hydrogen at a very low temperature being in our everyday environment? Write a brief scenario about the kinds of accident cases doctors might see appearing in hospital emergency rooms if we had a hydrogen powered economy.

SUBJECT: Science, English, Social Studies

ACTIVITY:

1. Write a futuristic scenario about the U. S. A. functioning on a hydrogen economy. In writing the scenario, consider the following questions - The methods by which hydrogen can be manufactured and stored, how it can be used as fuel and whether or not it would be burned directly in the air or other methods. Include the advantages and disadvantages of your hydrogen economy. (See the January 1973 issue of 'Scientific American', "Hydrogen Economy" for information on this topic.)

OBJECTIVE: To discuss a variety of examples of energy waste in modern society.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science

ACTIVITY:

1. Given a list of the following modes of transportation - train, bus, automobile - correctly rank order them in terms of their energy efficiency. Be able to explain.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:

1. Construct a list containing a minimum of eight examples of energy wasting common in the average American home. Suggest ways in which energy can be more fully utilized.

2. Discuss any energy conserving practices which you have developed over the past six months or which you plan to pursue during the next six months. Explain how much energy will have been saved. What are the costs in terms of money, time, other?

3. Prepare a presentation on the history of household appliances or work-saving machines showing the relationships of the machines to the source of energy by which they operate. Which are dependent on only one source of energy? Which are universal? List the machines/appliances that conserve non-human energy sources. Could they be used today?

SUBJECT: Science, Social Studies

ACTIVITY:

1. Given the categories - schools, industry, transportation, entertainment, homes - provide a minimum of two examples of energy-wasting practices in each category.

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:

1. Given the topic sentence "The following energy-saving practice would not have a negative effect on my life style", write a minimum of one paragraph describing an energy-saving practice which would not produce an adverse effect on a student's life style.

2. Given a list of five common energy-wasting practices, select two of these and propose a non-technical method of conserving some of the energy being wasted.

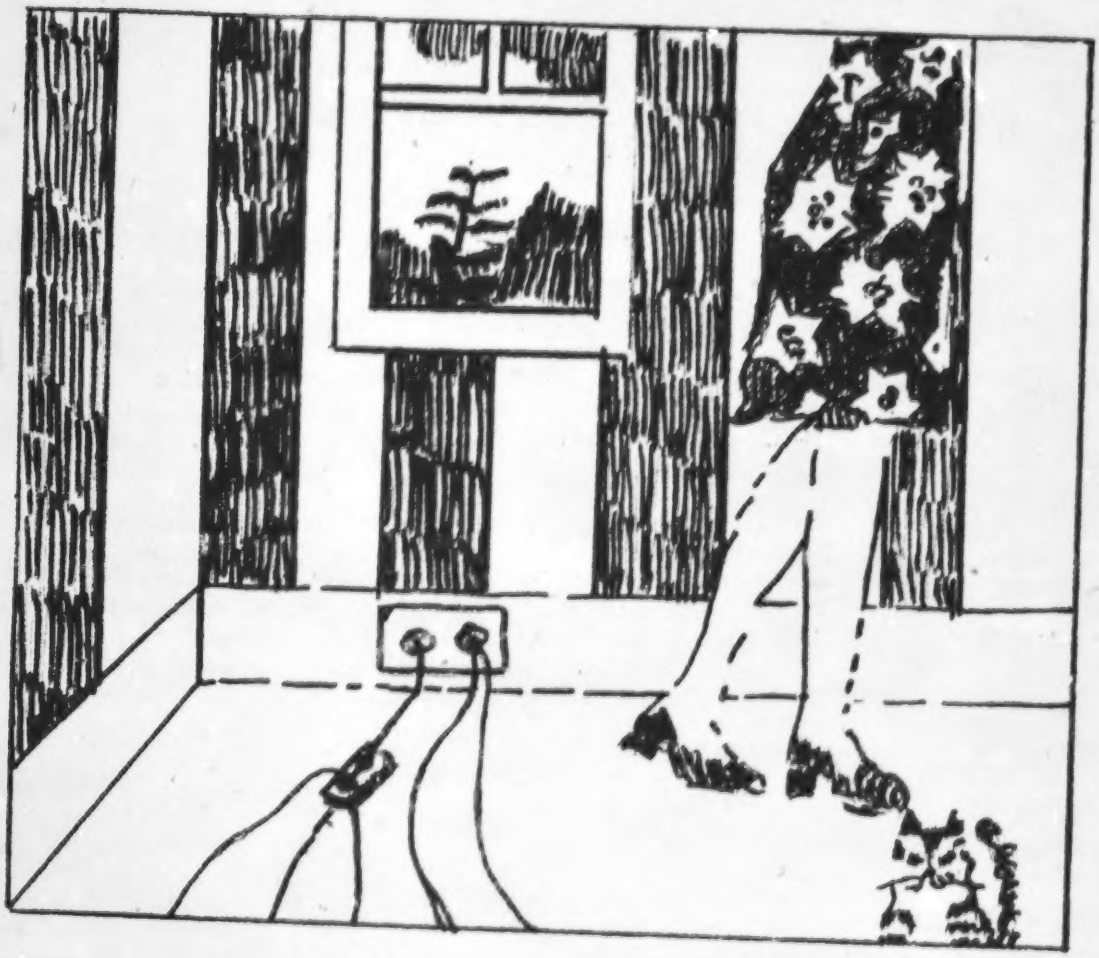
GRADE LEVEL: 10-12

SUBJECT: Science, Language Arts, Social Studies

ACTIVITY:

1. Design a transportation system for a hypothetical nation which would use energy more efficiently than the American transportation system. Make a series of proposals which, in the opinion of the teacher and/or the class, are accurate and would result in energy savings. Of course, you will have to define the country first - size, terrain, geographical position, population, etc.

2. Identify a minimum of five energy-wasting practices in your local community and propose some reasonable solutions which would result in energy savings.



OBJECTIVE: To evaluate proposals for energy conservation and efficient energy use in terms of energy wasting in our society.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science, Social Studies, Language Arts

ACTIVITY:

1. You are in charge of advertising for an energy producing company. In the past your philosophy has been based on 'Bigger is better". Also, your company has allowed reduced rates to large-scale users of their energy. How might your campaign change in light of the current "energy crisis"? (Remember the ads must appeal to both large consumers and the individual home owner or small businessman).

SUBJECT: Science, Art

ACTIVITY:

1. Propose as many ways as possible for saving energy in your home, your school, and at a shopping center. Decide as a class which are the best and prepare posters to encourage these practices.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Art, Language Arts, Social Studies

ACTIVITY:

1. In cartoon style, demonstrate some ways in which fossil fuels could be conserved in your home, school and/or community. Present your cartoons to a class of younger children.

2. Prepare a presentation which shows how the preservation and rehabilitation of buildings conserves energy. For background information consult "Preservation and the Energy Crisis" in 'Historic Preservation', April-June 1971 by Mark Lotus, and 'Preservation News', (Editorial) January 1971, also the 'Architectural Forum' - "Energy's Impact on Architecture", Summer 1973.

GRADE LEVEL: 10-12

SUBJECT: Science, Mathematics

ACTIVITY:

1. Do some research on the following: To heat 50 gallons of water from 32 degrees F to 212 degrees F requires 75,000 BTU's of energy. The conversion from electrical energy to heat can be assumed to be 100 percent efficient. How much energy in the form of electricity is needed to heat the water? In conventional generators, the production of electrical energy from a fossil fuel, such as natural gas, is only 32 percent efficient. How much

energy in the form of natural gas is necessary to produce the electrical energy? If there are approximately 1030 BTU's/cubic foot of natural gas, how much natural gas is needed? A natural gas water heater is 62 percent efficient. If the same 50 gallons of water is to be raised by the same amount, how much natural gas would be needed? Which is the more efficient process? By how much?

SUBJECT: Science, Social Studies

ACTIVITY:

1. Visit a local utility plant in your area. Find out what their attitude is toward conservation of energy and whether or not the attitude has changed since the "energy crisis". If so, how has their advertising and policy towards customers changed? Report your findings to the class.

SUBJECT: Science, Art, Social Studies, Language Arts

ACTIVITY:

1. Prepare a photographic essay on the different uses of energy in your town. Include effects of energy use on the environment. Where possible, illustrate wasteful practices. Present to a group such as students, parents, or clubs (Rotary, Kiwanis, etc.)

SUBJECT: Science, Language Arts, Social Studies, Mathematics

ACTIVITY:

1. How much energy is wasted by the automobile? What areas of the automobile waste energy? Make a list of them and check your list with accepted sources. The overall efficiency of the automobile is less than 20 percent. The energy available to the engine of an automobile is equal to the amount of gasoline times the heat combustion of the gasoline. If 10 gallons of fuel are available and the heat of combustion is 119,000 BTU/gal. how much energy is available to the engine? If the efficiency of conversion is only 20 percent, how much energy is available to power the vehicle? If the average car uses 750 gallons of gasoline a year, how much energy is wasted per year per car? At present there are more than 110,000,000 cars in the United States. How much energy is wasted per year in the United States by automobiles? Present a report to the class. Perhaps a photographic essay would be possible.

OBJECTIVE: To determine future energy demands.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9
10-12

SUBJECT: Science, Social Studies

ACTIVITY:

1. Prepare a bulletin board for purpose of discussion. The object of your display is to compare the energy flow of a hunting society, an agricultural society and an industrial society. Attempt to illustrate how these societies waste energy, where the least and the greatest amount of waste occurs (include human energy too), the form in which the greatest amount of energy is lost, and which society makes the most efficient use of its energy. Discuss with your classmates which society they would choose to live in and whether or not third world nations should be encouraged to industrialize. (For information on this topic, there is a series of articles in the September 1972 issue of 'Scientific American', "The Flow of Energy in a Hunting Society", "The Flow of Energy in an Agricultural Society", and "The Flow of Energy in an Industrial Society" which may be helpful resources.)

SUBJECT: Science, English, Art, Social Studies

ACTIVITY:

1. The comic strip "Little Abner" has a character or cast of characters called "schmoos". These animals were anxious to be of service to mankind insofar as they only wished to be eaten, and would assume the appearance and flavor of whatever food the consumer wanted. They propagated on demand, and were the fantasy solution to the world's food problems. Students will create a fantasy solution to the world's energy problems and create a comic strip to depict it.

GRADE LEVEL: 10-12

SUBJECT: Science

ACTIVITY:

An article entitled "Energy and Power", by Chauncy Starr, was published in 'Scientific American' (Volume 225, No. 3, 1971). On page 39 of this article, there appears a graph which shows projected energy demands for all types of energy for the United States from 1850 to the year 2000. If this article is available, examine this graph carefully. Make some statement about the rate of energy consumption in each of the twenty-five intervals from 1850 to 1950. Why is the portion of the graph depicting hydroelectric

power relatively constant over time. What form of energy shows the greatest growth between 1900 and 1975. (If the article is not available, obtain the necessary information via library research.)

SUBJECT: Science, Mathematics

ACTIVITY:

1. The following are estimates of the reserves of fossil fuel in the United States in 1968 - coal - 1580 billion tons remaining, 1968 production rate 0.55 billion tons/year. Oil - 165 billion barrels, 1968 production rate 3.4 billion barrels/year. Natural gas - 19.3 trillion cubic feet/year. If we continue to use these fossil fuels at the same rate as we did in the past, how long will they last? Draw a graph for oil, coal and natural gas that shows the production rate since 1900 to the year 2050. Along with your graph, try to answer some of the following questions. Since 1968, discoveries have been made of more resources (such as the north slope oil field in Alaska). How many barrels of oil were found in Alaska? How long will this extend our supplies of oil? Do you think that the production rate has remained constant since 1900? Do you think it will remain constant in the future? How will price increases such as recent ones for all of the fossil fuels affect production rate? How do you think your graphs of the production rates will be altered in the future?

2. Given a hypothetical set of data outlining the consumption of petroleum products from the year 1920 to the year 1970, extrapolate the consumption of petroleum products in the year 2000.

3. Given two sets of data, one which depicts the growth of American population from 1920 to 1970, the other depicting the growth of American electrical consumption for the same period, compare these two sets of data and arrive at a conclusion relating the two. Based upon this finding, propose a minimum of one plausible reason for this phenomenon.

SUBJECT: Science, English, Social Studies

ACTIVITY:

1. A number of books have been written over the past few years known as "Doomsday Books" because of their projections about future societies. Read one of these books (Such as 'The Limits to Growth' by D. Meadows, et al., University Books - 'World Dynamics' by Jay Forrester, Wright-Allen Press - and 'Urban Dynamics' by Jay Forrester, M.I.T. Press) and write a reaction paper to the book that

includes your opinion of the author's views, whether or not you find holes in his arguments, and what your projection of the future is.

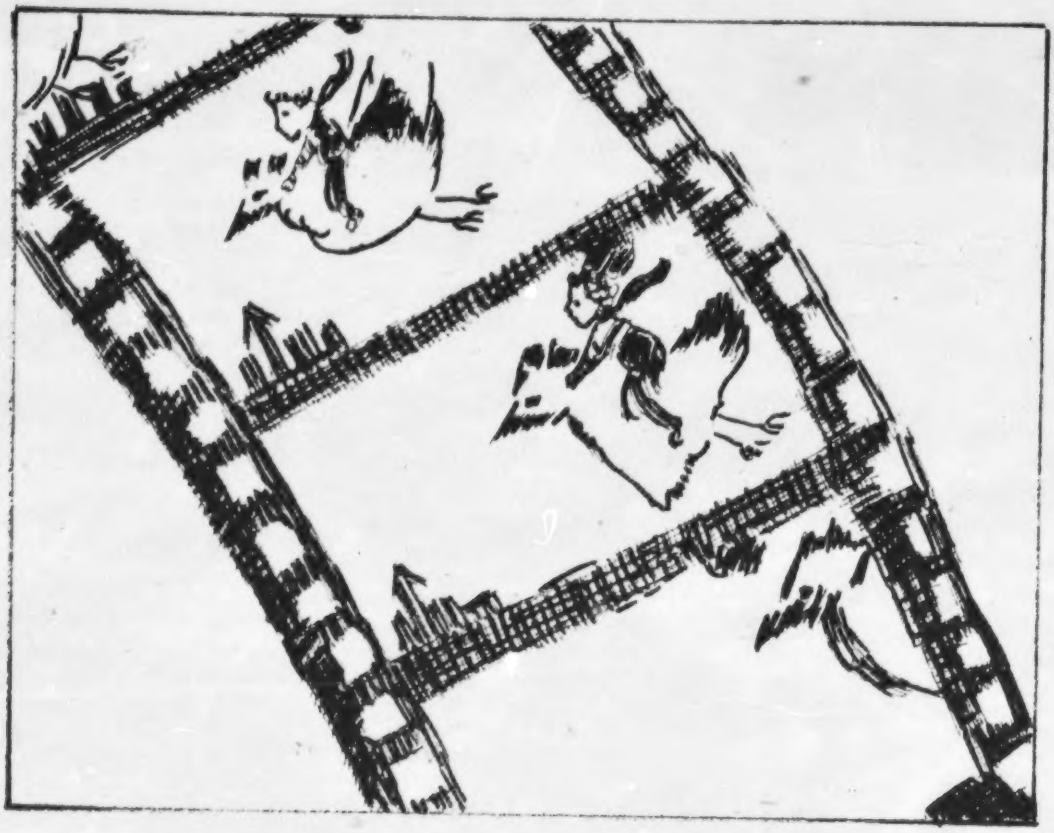
2. Prepare a debate for an assembly, P.T.A., etc., based on the following statement - "To make our country self-sufficient energy wise, it is imperative to move full speed ahead on off-shore oil drilling (and/or solar energy, and/or nuclear energy, etc.)".

3. Write a futuristic scenario of the effects on the American economy should one energy source be depleted. Include political, social and environmental ramifications that might occur as a result of economic change.

SUBJECT: Science, Language Arts, Art, Social Studies

ACTIVITY:

1. Write a scenario describing what life would be like in the year 2074 if automobile usage continues at the present rate. The scenario might make a good film or filmstrip.



OBJECTIVE: To compare various forms of energy.

PROBLEM AREA: Energy - Technology

GRADE LEVEL: 7-9

SUBJECT: Science, Art

ACTIVITY:

1. Create a large world map that illustrates the location of the earth's fuel supplies (e.g., coal, oil, gas, uranium). Indicate the type of nation (e.g., agricultural, industrial) and the type of fuel(s) on which it depends. If possible, include size of reserves and projected time of depletion. Complete your map with symbols and legend.

2. Construct a mural showing the historical progression of fuel uses, from wood to what is proposed for the future - possibly nuclear fuel, or solar energy. Included in the depiction should be wood, peat, lignite, coal, oil, natural gas, nuclear fission and nuclear fusion.

3. Create a mural showing the evolution of fossil fuels from early plant life to use by man or, if desired, class could work on stages in the history of energy used by man (i.e., slaves, animals, windmills, waterwheels, wood, steam, etc.)

4. Following a discussion on the use of the "symbol" historically and its use in our present culture, design a symbol or logo for an energy organization (nuclear, electric, fossil fuel, etc.). (Considerations that should be brought out in the discussion include everyday use of symbols, concepts behind symbols, the historical use of symbols, universal and regional symbols, purpose of symbols, etc.)

SUBJECT: Science, Manual Arts

ACTIVITY:

1. Diagram the way in which a windmill works, and describe some of its uses. Then, construct a model of a windmill. Compare the type of energy used by a windmill to the energy derived from wood, coal, natural gas and oil.

GRADE LEVEL: 7-9
10-12

SUBJECT: Science

ACTIVITY:

1. Select several forms of energy (e.g., solar, fossil fuel, nuclear) and compare them in as many ways as possible such as location and amount of source, means of transportation, use, level of development, economic feasibility,

social and political pressures, effects of environment, and future possibilities. Make a chart showing your findings.

2. Divide the class into groups. Have each group plot one method of how heat and/or electrical power goes from its source to a home (i.e., coal mine, oil field, gas field, nuclear generating plant, water dam). Include the means of transportation. Also show the effects on the environment at each step in the process. Present to class and discuss the advantages and disadvantages of each method. Compare the effects on the environment.

3. Select a form of energy production. What research (and by whom) is being undertaken towards conserving and/or making more efficient use of this form of energy? Who are the greatest and least users of this energy? Where do the greatest losses of energy occur? What advertising (and at whom is it directed) pleads for energy's conservative use? Make suggestions for conserving this energy source. You might want to include these answers in a brief written report.

SUBJECT: Science, Art

ACTIVITY:

1. Create a display which illustrates how a form (or forms) of energy is generated (e.g., solar, nuclear, geothermal).

2. Design a postage stamp, with the theme of energy. The tone of the stamp should be optimistic and patriotic. Study other postage stamps to get the general feel of what is usually done. Do a large sketch of your plan, with a mock-up of the stamp in the size you intend it to be. Paste both on display board.

3. Select a source of energy (e.g., coal, oil, gas, uranium, sun) and create a display which illustrates how that source(s) affects society's needs (e.g., transportation, food production, electrical power, recreation, heat and cold production). Include also the amount and projected depletion date of the energy source and the effects on the environment caused by the use of that form of energy.

SUBJECT: Science, Social Studies, Language Arts

ACTIVITY:

1. Investigate the history of the development of an energy source (e.g., nuclear, solar). Present your findings to the class (written, oral, or display).

SUBJECT: Science, English, Social Studies

ACTIVITY:

1. Do a biographical sketch (written or performed) of a person who has contributed to the energy field (e.g., Einstein, Fermi).

SUBJECT: Science, English, Social Studies, Art

ACTIVITY:

1. Prepare a slide show depicting types of energy used in the community, as well as any pollution the use of energy encourages. A student commentary should be prepared to accompany the show. Show your slide show to appropriate audiences.

GRADE LEVEL: Science, Mathematics

ACTIVITY:

1. In the September 1971 issue of 'Scientific American' is an article, "Energy and Power". In the article is a graph of the United States energy consumption from 1850 to the year 2000. Can you accurately project further into the future? Using data from the graph, make a graph of the total energy consumption as a function of time, but use semi-log graph paper. Plot the total energy on the vertical (log) axis. Does this graph give a more accurate means of projecting energy demands? Look carefully at the time spans between 1900-1930, 1930-1950, and 1950 to the present.

SUBJECT: Science, Social Studies

ACTIVITY:

1. Write or call your local utility plant and find out if they will send someone to talk to your class about alternate energy sources (e.g., nuclear energy). Prepare questions in advance, such as - projected energy needs for your community and if they can be met through standard methods - advantages and disadvantages of alternative methods - political, social and economic pressures that might affect constructing alternative methods - future for the environment, etc.

2. For one or two weeks, select advertising which deals with energy production, and; A) summarize facts that are presented, B) check facts with standard reference books (encyclopedia, almanacs or other public documents), C) analyze the purpose fo the ad or TV/radio commercial, D) estimate the cost of advertising for the one/two week period and E) form an opinion as to the value of such advertising.

SUBJECT: Science, Social Studies, Art

ACTIVITY:

1. Locate advertisements dealing with energy production in several types of newspapers and magazines (i.e., consumer oriented magazines, trade magazines, industrial newspapers). Make a bulletin board display or other form of visual arrangement that illustrates how advertising is directed at different audiences. With your classmates, discuss the types of appeals used, the psychology behind the appeals, the validity of the appeal, the cost of the advertisement and how you think the audience will react to the ads. You might also compare past advertising with what has evolved since the "energy crisis".

INTERESTING SUPPLEMENTARY REFERENCES

BOOKS:

Science, Discovery and Progress, Ira C. Davis, et al. Holt, Rinehart, New York. 1970. Contains material on energy and many activities for students, particularly at the secondary level. Explanations of the laws of energy. Excellent reference for teachers.

Energy for the Future: New Directions and Challenges, S. C. Bechtel, Jr. American Gas Association, Cincinnati, Ohio. 1973. Reprint of a convention report. States that we are using more energy than we produce and that this gap is an ever-widening one. Deals with the complexities of the proper evaluation of alternatives.

Dimensions of Change, Don Fabun. Glencoe Press, Beverly Hills, California. 1971. Profusely illustrated book which shows the role of energy not only in our country, but in the world. Easy to read.

Energy, M. Wilson and The Editors of Time-Life Books. Time-Life Books. New York. 1967. Explains the role of energy in the universe and how matter is transformed to energy. Basic types of energy are described. Well illustrated.

The Conquest of Energy, G. R. Harrison. William Morrow & Co., New York. 1968. Discusses the importance of energy, its sources, uses and transportation. Entertains the thesis that our energy base will shift from fossil fuel to solar and nuclear energy. Optimistic viewpoint. Indexed.

FILM:

Atomic Energy, EBE, 425 N. Michigan Avenue, Chicago, Ill. B/W 11 minutes. Purchase price - $70. Identifies with animated drawings parts and structures of atoms. Defines and contrasts electronic or chemical energy and nuclear energy. Illustrates relationship between atomic energy from the sun and chemical energy stored and released in photosynthesis and combustion.

PAMPHLETS:

Energy Resources of the United States, U. S. Geological Survey, Washington, D. C. Circular No. 650. Free. A comprehensive government publication discussing United States energy resources in detail.

8 Page Special Report on Energy, National Wildlife Federation, 1412 16th St., N. W., Washington, D. C. 20036. Single copies free - additional copies $.10 each. Excellent review of subject. Why a shortage now? Our dependence on fossil fuels, conservation and energy alternatives.

PERIODICAL:

Science Magazine. April 1971, Volume 184, No. 4134, American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. W., Washington, D. C. 20005. Single copy - $2.00. Total issue devoted to energy: energy use for food, problems of expanding coal production, nuclear power, geothermal and solar energy, etc. Closest thing to a comprehensive and definitive reference available. In print now as a paper cover book.